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Prospects for wind energy in Australia

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Beyond Zero Emissions Discussion Group, 6/10/08

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Outline

- Global energy-related challenges:
 - Energy security, fossil fuel prices, climate change
- Implications for the stationary energy sector
- Complex technological systems – the stationary energy sector
- Wind energy resource & technology issues
- Issues in integrating large amounts of wind energy into the Australian electricity industry
- Conclusions
- Appendix: small wind turbines

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Background

- Humans face serious energy-related challenges:
 - Fossil fuel flow constraints:
 - "Peak-oil" now & in future "peak-gas", "peak-coal", "peak-uranium"
 - Energy security concerns:
 - Unequal distribution of energy resources among nation states
 - Increasing risk of dangerous climate change:
 - Anthropogenic CO₂ & other climate change gases
- These challenges are primarily matters of equity:
 - Intra-generational: rich versus poor
 - Inter-generational: old versus young & future generations
 - Our best hope is frugality but we prefer to party*

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Implications for the stationary energy sector (non-transport energy use)

- Need to rapidly de-carbonise the sector:
 - "...solution to global warming must include phase-out of coal except for uses where the CO₂ is captured and sequestered" (Hansen letter to Rudd, 27/3/08)
- CCS not commercially available for at least 15yr:
 - "we think that 2020 is the earliest it [ccs] can really be commercialised" (John Boshier, National Generators Forum, ABC 7.30 Report, 7/4/08)
- Key near-term options are:
 - Frugality & improved end-use efficiency
 - Coal-to-gas & renewable energy technologies

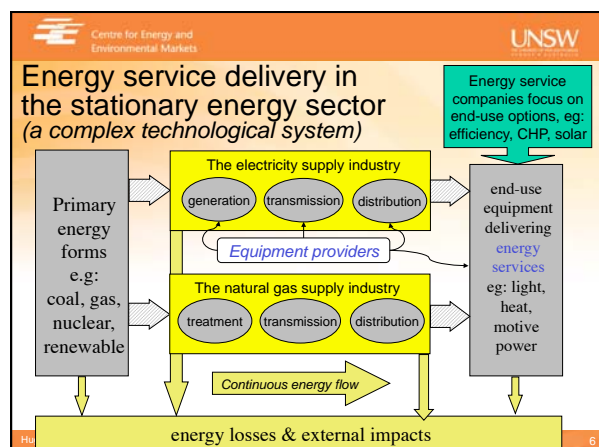
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Trend to gas-fired generation in the NEM: committed capacity & expected gas use (ESIPC-SA APR, 2008)

	Currently	2009	2010
Total Capacity	6500 MW	8500 MW	9700 MW
Fuel consumption	160 PJ	220 PJ	280 PJ

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What is technology?

(www.iiasa.ac.at)

Software & orgware are critical issues in complex technological systems such as an electricity industry

The Art of Knowing and Doing
The study of **technology** concerns *what* things are made and *how* things are made. Technology, from the Greek *science of (practical) arts*, has both a *material* and an *immaterial* aspect.

Technology = Hardware + Software + "Orgware"



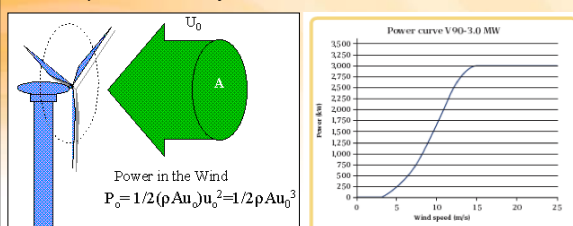
Hardware: Manufactured objects (artifacts)
Software: Knowledge required to design, manufacture, and use technology hardware
"Orgware": Institutional settings and rules for the generation of technological knowledge and for the use of technologies

Technology's most important characteristic: **Continuous change >>**

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Wind power density & wind turbine conversion curve



Power in the Wind
 $P_0 = 1/2(\rho A u_0^3) = 1/2 \rho A u_0^3$

- Doubling wind speed increases wind power density 8 times
- A wind turbine is designed with a varying conversion efficiency of up to ~50% between 5 and 10 m/s

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A modern 3MW wind turbine (www.vestas.com)



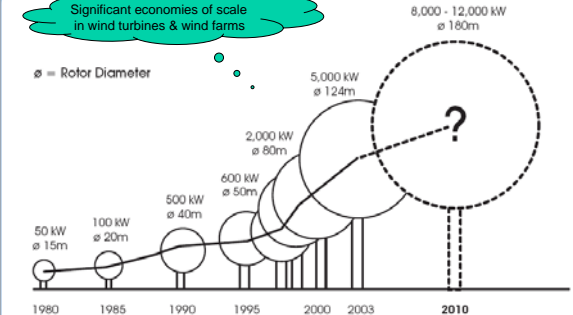
Technical specifications

- oil cooler
- water cooler for generator
- high voltage transformer
- ultrasonic wind sensors
- pitch controller with inverter
- torque converter
- cyclo-synchronous generator
- composite disc coupling
- yaw gear
- gearbox
- technical disc brake
- machine foundation
- blade bearing
- blade hub
- blade
- pitch cylinder
- hub controller

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Significant economies of scale in wind turbines & wind farms



• Rotor Diameter

• 50 kW ø 15m

• 100 kW ø 20m

• 500 kW ø 40m

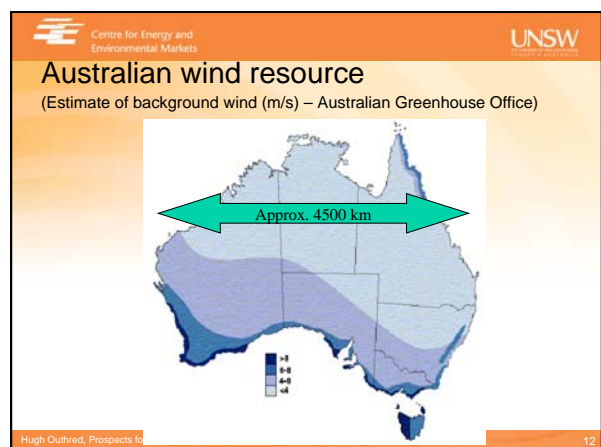
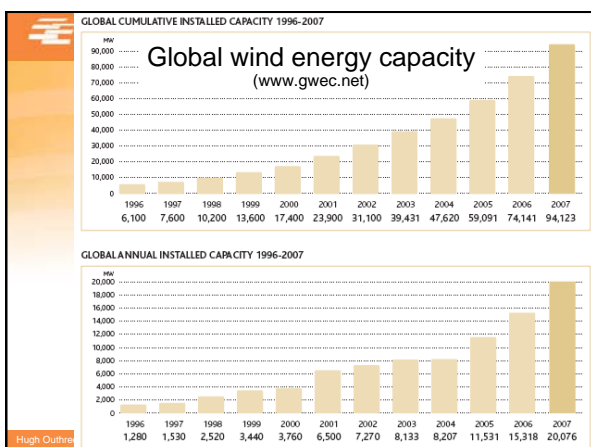
• 2,000 kW ø 80m

• 5,000 kW ø 124m

• 8,000 - 12,000 kW ø 180m

Growth in the size of commercial wind turbines. (European Commission, 2005)

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Some Wind Farms in Australia

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Wind farms marginal at \$70/MWH (PWC, 2002)

Impact of Wind Speed and PPA Prices on IRR

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Cost & CO2 coefficients for new generation (ESIPC Annual Planning Report, 2008)

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Proposed MRET target of 20% by 2020

- Rules still to be finalised but possibly >45TWH pa in 2020
- A scenario for resulting renewable energy generation shown below
- Possible high wind penetration in SA + Vic

(IES, NSW Privatisation Conference, 2008)

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Wind energy in the Australian NEM

- Presently ~1GW, but 8GW likely in <10 years, including ~2.5GW in South Australia (diag below)
- NEMMCO is installing an Australian Wind Energy Forecasting System purchased from Anemos
- AWEFS will be integrated into the NEM forecasting process (pre-dispatch, STPASA, MTPASA, SOO)

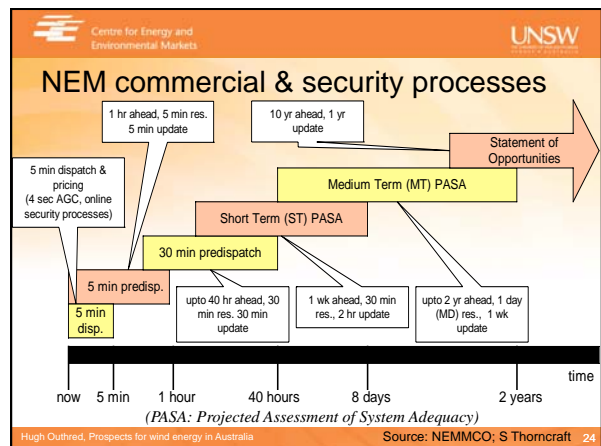
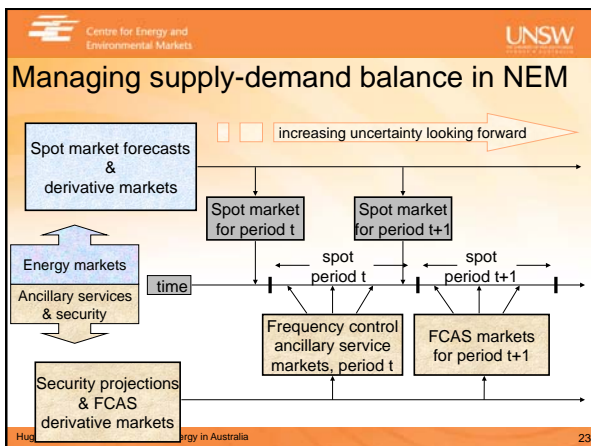
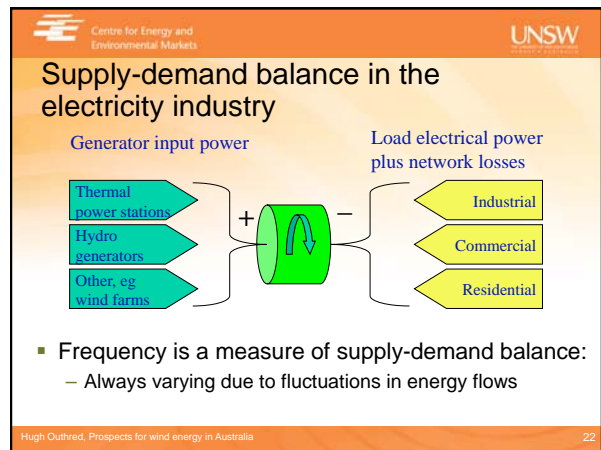
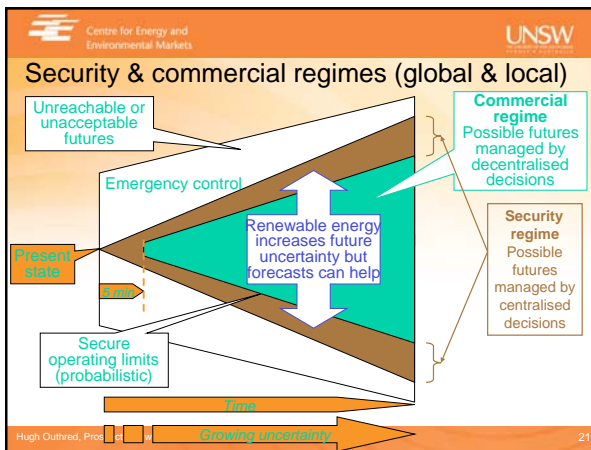
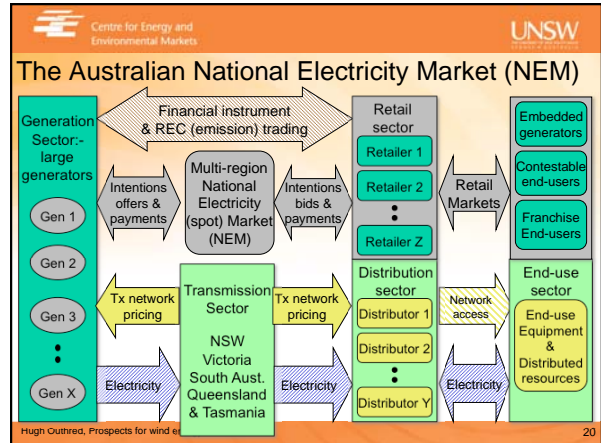
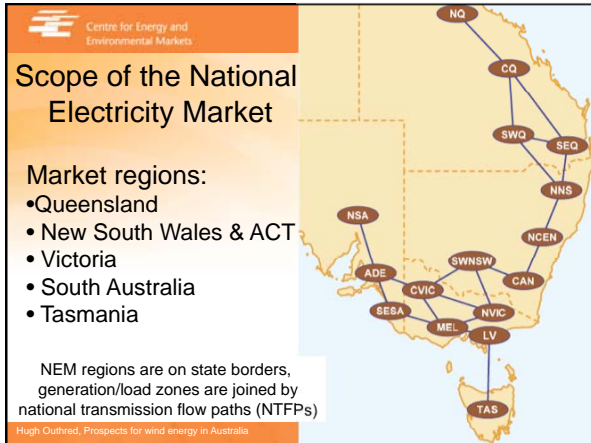
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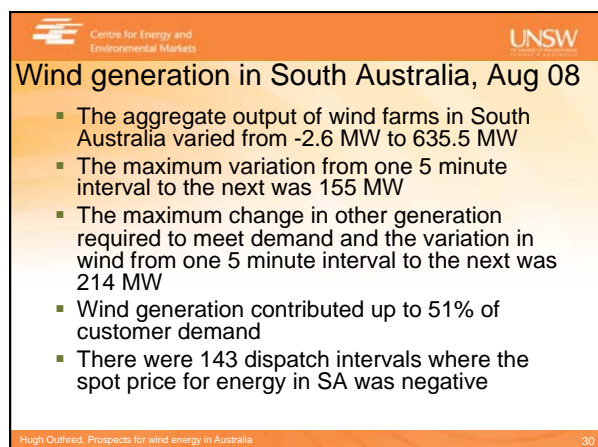
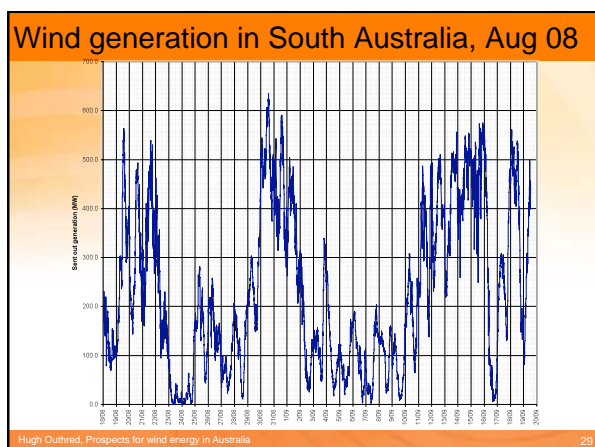
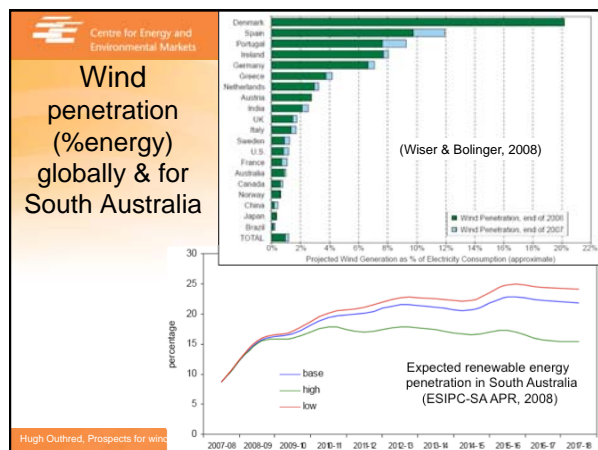
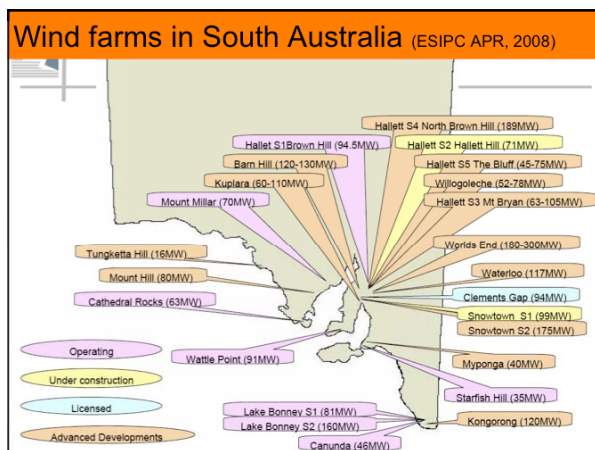
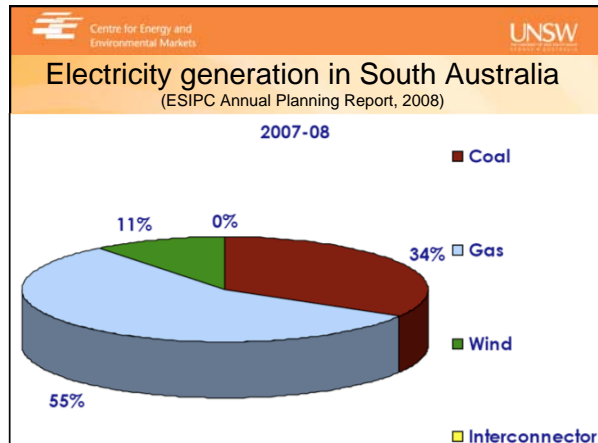
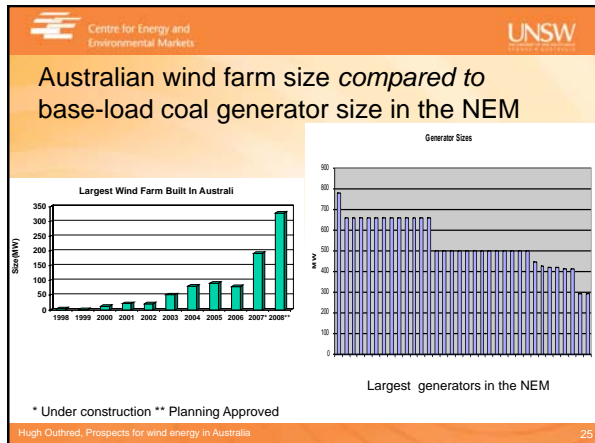
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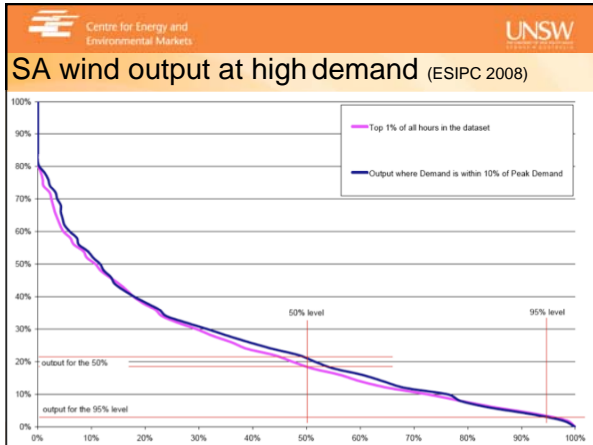
Decision-making framework for a restructured electricity industry (EI)

Governance regime	<ul style="list-style-type: none"> Formal institutions, legislation & policies Informal social context including politics
Security regime	<ul style="list-style-type: none"> Responsible for core integrity on local or industry-wide basis, with power to override
Technical regime	<ul style="list-style-type: none"> Engineering design to allow industry components to function as single, industry-wide machine when connected together
Commercial regime	<ul style="list-style-type: none"> Decentralised decision-making according to commercial criteria within a market context Includes formally designed markets Needs adequate competitive pressures

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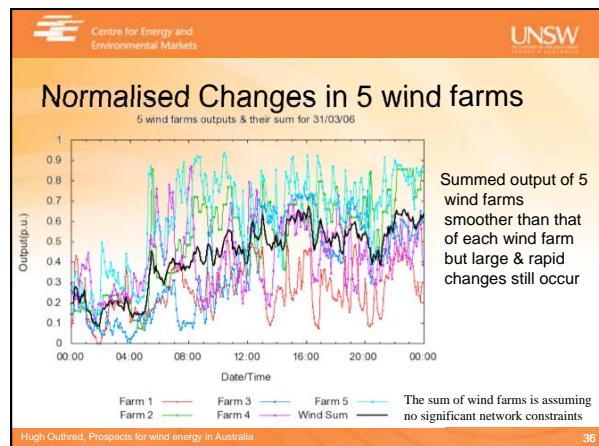
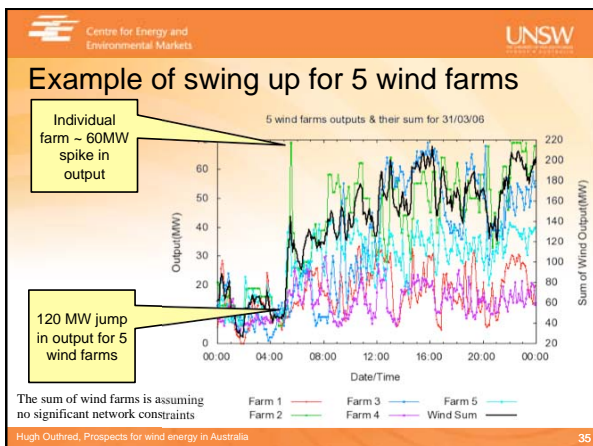
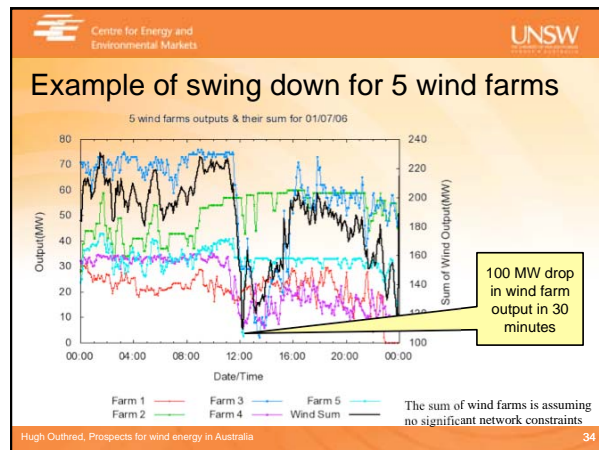
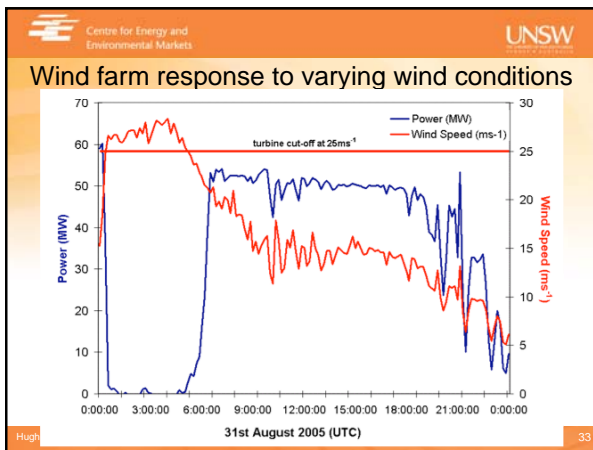


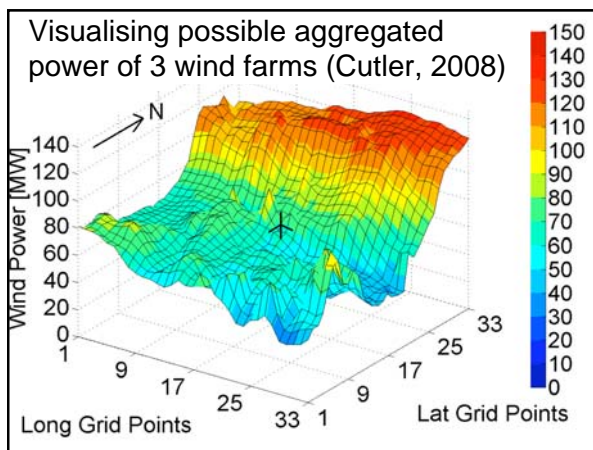
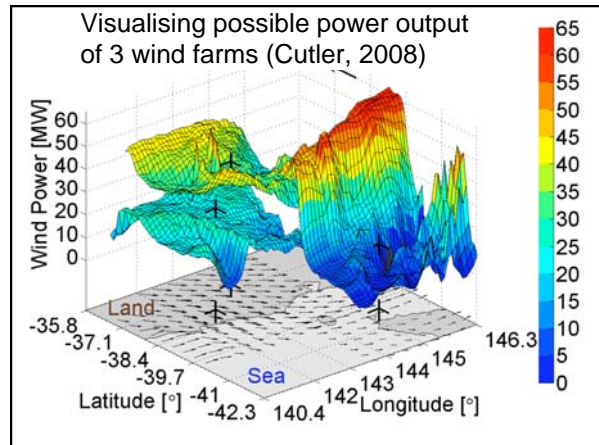
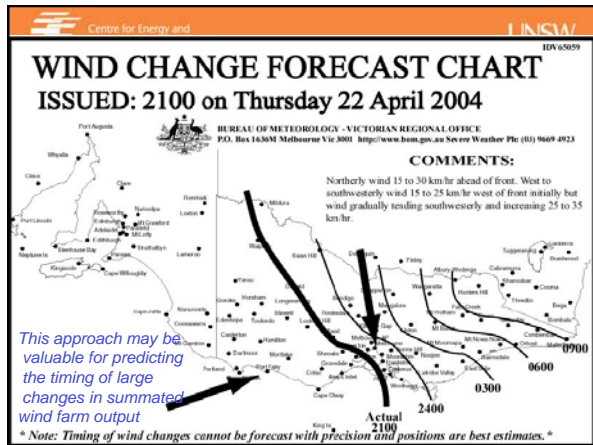




NEM income for SA wind & other generators (ESIPC-SA APR 2008)

Year	Volume Weighted Price for Wind Generators		Volume Weighted Price for Other SA Generators	
	Full Year (\$/MWh)	Summer (\$/MWh)	Full Year (\$/MWh)	Summer (\$/MWh)
2004-05	NA	NA	39.25	32.62
2005-06	32.57	39.59	43.91	67.50
2006-07	49.69	51.55	58.71	67.21
YTD 2007-08	66.99	63.94	108.25	149.92





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Key electricity industry issues for high-penetration renewable energy #1

- Structural issues:
 - Robust security regime with security-constrained dispatch
 - Efficient commercial regime (operation & investment)
 - Effective regulation of network services
 - Compatible arrangements for gas industry
- Development issues:
 - Innovation in renewable energy technologies
 - Forecasting for security & commercial regimes
 - Active end-user participation (value, timing, efficiency)
 - Education & training in all relevant areas

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Key electricity industry issues for high-penetration renewable energy #2

- Auction-style, security-constrained markets:
 - For spot energy, ancillary services & derivatives
 - Active end-users supported by ESCOs & equity policies
- Efficient network service regime:
 - Augmentation; availability & quality; distributed resources
- Renewable energy forecasting tools for:
 - Security, commercial & governance regimes
- Internalisation of un-costed fossil fuel externalities:
 - Carbon taxes or rigorous emissions trading scheme
 - Development & deployment of low emission technologies

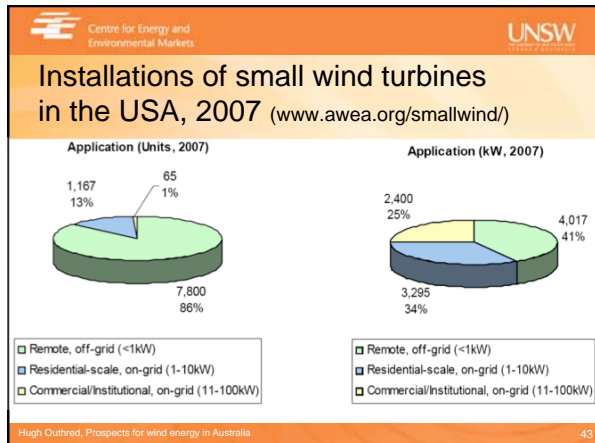
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Conclusions


- Sustainability challenges are of global-scale:
 - Fossil fuel availability & pricing
 - Climate change
 - Also food, water and other resources
- Electricity industries must contribute to solutions:
 - Efficient & frugal end-use
 - Low-carbon, locally available primary energy resources
- Wind energy has an important role to play:
 - Active community participation to align projects with community attitudes & expectations
 - Enhanced forecasting & power system security regime

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Small wind turbines



- Defined by AWEA as <100kW
- Market growing more slowly than for large turbines:
 - More expensive (\$/W); turbines less reliable; less suited to grid connection; weaker & more turbulent winds; concerns about noise, accidents & visual impacts
- Internet resources for small wind turbines:
 - www.awea.org/smallwind/; www.nrel.org/wind/
 - www.bergey.com/School/Primer.html

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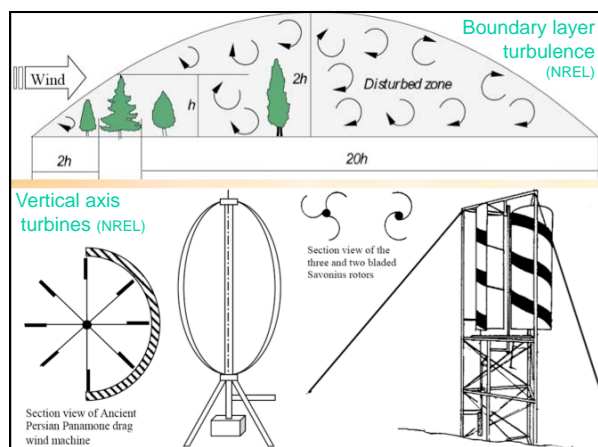
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Proven Energy small wind turbines

(www.provenenergy.co.uk)
2.5kW, 6 kW & 15 kW
downwind, direct drive




15 kW (9m dia, 15m hub)





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